Design and Fabrication of efficient energy harvesting Nanogenerators

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I. Nanogenerator

A nanogenerator is any nano scale device used to generate power.It may be any generator that uses Nano scale tools, like nanowires to generate electricity.Various parts of nanogenerator are Base electrode, vertical piezoelectric nanostructure, counter electrodeas shown in fig.1.

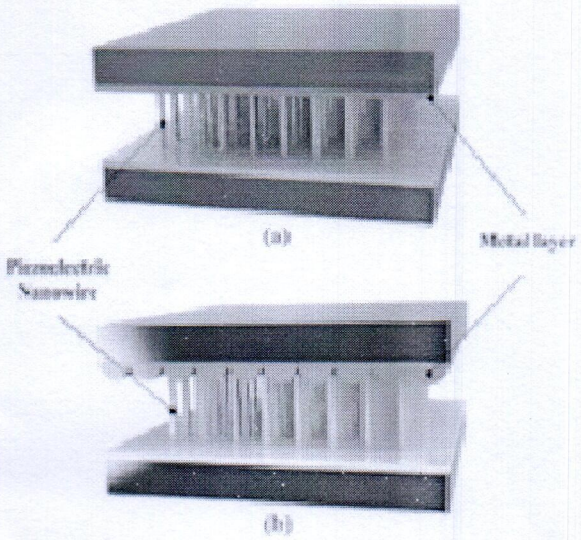
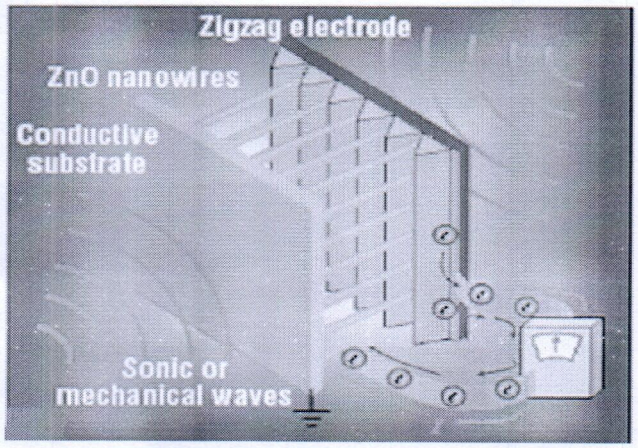


Fig. 1

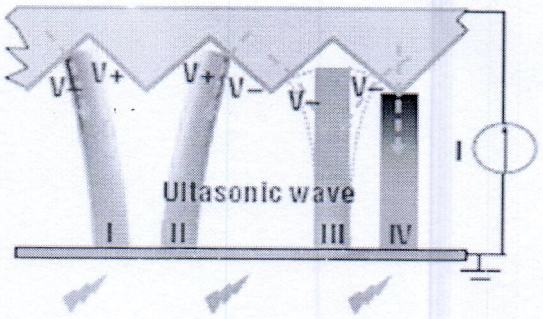
II. A wave or vibration driven nanogenerator

Figure 2(a), schematically shows a zigzag silicon electrode coated with platinum covers an array of aligned ZnO NWs. The platinum coating isn't only for enhancing the electrode's conductivity but also for creating a Schottky diode at the interface with ZnO. The electrode is placed above the NWarrays, manipulated it from a controlled distance, and carefully packaged it to separate the electrode from the NWs. The design relies on a unique coupling between the aligned ZnO NWs' piezoelectric and semiconducting properties. The asymmetric piezoelectric potential across the width of a ZnO NW and the Schottky contact between the metal electrode and the NW are the two key processes for creating, separating, preserving and accumulating, and outputting the charges. The top electrode is designed to achieve the coupling process and play the AFM tip's role, and its zigzag trenches act as an array of aligned AFM tips. When subjected to the excitation of an ultrasonicwave, the zigzag electrode can move down and push the NW. This

leads to a lateral bending, which creates a strain field across the NW's width, so the NW's outer surface is in tensile strain and its inner surface in compressivestrain. When the electrode contacts the NW's stretched surface, which has a positive piezoelectric potential, the platinum metal – ZnO semiconductor interface is a reversely biased Schottky diode, resulting in little current flowing across the interface (see figure 2b).This process creates, separates, and preserves and accumulates charges. If we further push the electrode, the bent NW will reach the other side of the zigzag electrode's adjacent tooth. In such a case, the electrode is also in contact with the NW's compressed side, where the metal-semiconductor interface is a forward-biased Schottky barrier, resulting in a sudden increase in the output electric current flowing from the top electrode into the NW. This is the discharge process. This design works as long as there's a relative displacement between the electrode and the NWs, either vertically or laterally.



(a)



(b)

NW's tip's maximum deflection is given by equation

$$V_{max}^{(T,C)} = \pm \frac{3}{4(\kappa_0 + \kappa_\perp)} [e_{33} - 2(1+\nu)e_{15} - 2\nu e_{31}] \frac{a^3}{l^3} v_{max}$$

Where,

f_y is the transverse force for deflecting the NW;

K_0 is the permittivity in vaccum;

K_{11}=K_{22}= K_1 is the dielectric constant;

e_{31},e_{33}, and e_{15} are the piezoelectric coefficients;

v is the Poisson ratio;

a is the NW's radius;

v_{max} is the NW's tip's maximum deflection; and

l is the NW's length.

III. Advantages and potential applications

Mechanical-movement energy,

Vibration energy,

Hydraulic energy,

NWs can grow on any substrate at a low temperature,

NW-based nanogenerators work in a wide frequency range,

ZnO is biocompatible and environmentally

Friendly,

NWs have superelasticity and are very resistive to fatigue.

IV. Literature Survey

Sodano et al. [3] published a review article highlighting the previous literature on piezoelectric vibration harvesting.

Beeby et al. [1] published a review article highlighting previous works on piezoelectric, electrostatic, and electromagnetic harvesting for micro-scale applications.

L. Mateu and F. Moll [7] presented several different energy transducers for obtaining electrical energy from different types of energy available, including kinetic energy (piezoelectric generator, electrostatic energy generator and magnetic induction generator), electromagnetic radiation (solar energy, RF radiation) and thermal energy.

Cook-Chennault et al. [2] provided an overview of various energy harvesting sources for MEMS applications including solar harvesting, thermal harvesting, and vibration harvesting using electrostatic, electromagnetic, and piezoelectric devices.

Indrani Dakau [11] published a review article entitled "Piezoelectric Energy Generation and Harvesting at the Nano-Scale: Materials and Devices" and found that, throughout the reported research work done up until now, ZnO holds several advantages over other materials.

Yeong Hwan Ko, presented ZnO nanorod-based piezoelectric nanogenerators (NGs) with Au-coated silica sphere array as an efficient top electrode.

Qingliang Liao1, fabricate flexible piezoelectric nanogenerators (NGs) consisting of ZnO nanowires (NWs) on carbon fibers and foldable Au-coated ZnO NWs/ paper. The electric output of the NGs can be controlled by increasing the fiber number, adjusting the strain rate and connection modes.

Xudong Wang [8] published a paper reviewing the development of NGs (Nano-generators) from the fundamental principles to theoretical predictions to practical devices. Compared to conventional piezoelectric material based mechanical energy harvesters, using NWs (Nanowires) would potentially improve the energy conversion efficiency, enhance the sensitivity to low-level mechanical energy sources, and extend the device lifetime.

V. Challenges

First, we need to raise the nanogenerator's output voltage.

Second, we need to broaden the driving frequency span.

Third, we need 3D integration to raise the nanogenerators' voltage and current, which could raise the entire package's output power.

Fourth, we need to optimize the packaging technology.

Fifth, we need to explore energy-storage technology.

VI. Research plan

To improve the performance and efficiency of piezoelectric NG .

This could be done by replacing Zno nanowire by materials such as PVDF, indium nitride, gallium nitride, zinc sulphide, barrium titanate, and lead zirconate.

By using coating of different materials on top electrodes as well as bottom electrodes that provides efficient bending Of Zno nanorods on nanogenerator devices.This could be done by using different substrate materials such as Si, SiC, Polyethrsulphone, Polyethylene terapthalate .

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